CLAIMS

1. An information recording medium characterized by:

a plurality of information recordable recording layers, wherein a spiral or concentric tracks are formed on each of the plurality of recording layers, and at least a portion of each track has wobbles corresponding to a wobble signal that includes layer information for discriminating a recording layer on which the track is formed.

2. The information recording medium as claimed in claim 1, characterized in that at least a portion of each track has the wobbles corresponding to the wobble signal in which a layer information part including the layer information is modulated according to a predetermined modulation technique.

3. The information recording medium as claimed in claim 2, characterized in that at least a portion of each track has the wobbles corresponding to the wobble signal that further includes a carrier wave part for use in generating a reference clock.

4. The information recording medium as claimed in claim 3, characterized in that the layer information part is

arranged between 2 carrier wave parts.

5. The information recording medium as claimed in claim 3 or 4, characterized in that predetermined synchronizing information is recorded on each track at a predetermined synchronization period.

6. The information recording medium as claimed in claim 5, characterized in that at least a portion of each track has the wobbles corresponding to the wobble signal in which the layer information part is arranged at a period that is an integer multiple of the synchronization period.

7. The information recording medium as claimed in claim 5 or 6, characterized in that the layer information and the synchronizing information are recorded on the track with mutually different formats.

8. The information recording medium as claimed in claim 7, characterized in that the synchronizing information is recorded on the track as formation of pits.

9. The information recording medium as claimed in claim 7, characterized in that at least a portion of each track has the wobbles corresponding to the wobble signal that

further includes the synchronizing information modulated according to a modulation technique different from that of the layer information part.

10. The information recording medium as claimed in claim 6, characterized in that at least a portion of each track has the wobbles corresponding to the wobble signal that further includes the synchronizing information modulated according to a modulation technique identical to that of the layer information part.

11. The information recording medium as claimed in claim 10, characterized in that the layer information part and the synchronizing information part have mutually different signal waveforms.

12. The information recording medium as claimed in claim 10 or 11, characterized in that the modulation technique is a phase modulation technique.

13. The information recording medium as claimed in claim 12, characterized in that the 1 period of a reference clock generated from the carrier wave part amounts to 1 wobble, the synchronization period amounts to 93 wobbles, and the layer information part exists between a 12th wobble and an

88th wobble when the synchronizing information part starts from a 0th wobble.

14. The information recording medium as claimed in any of claims 5 to 13, characterized in that at least a portion of each track has the wobbles corresponding to the wobble signal that further includes address information.

15. A recording layer discriminating method for discriminating a recording layer on which a light spot is formed when accessing the information recording medium as claimed in any of claims 1 to 14, characterized in that the method comprises:

a first step acquiring the layer information from the wobble signal that is detected based on reflected light from the information recording medium; and

a second step discriminating the recording layer on which the light spot is formed based on the layer information.

16. A recording layer discriminating method for discriminating a recording layer on which a light spot is formed when accessing the information recording medium as claimed in claim 14, characterized in that the method comprises:

a first step acquiring the layer information and the

address information based on reflected light from the information recording medium; and

a second step discriminating the recording layer on which the light spot is formed based on the layer information and the address information.

17. A recording layer discriminating apparatus for discriminating a recording layer on which a light spot is formed when accessing the information recording medium as claimed in any of claims 5 to 14, characterized in that the apparatus comprises:

demodulating means for demodulating the wobble signal that is detected based on reflected light from the information recording medium; and

layer information detection means for detecting the layer information from the wobble signal that is demodulated.

18. A recording layer discriminating apparatus for discriminating a recording layer on which a light spot is formed when accessing the information recording medium as claimed in claim 14, characterized in that the apparatus comprises:

demodulating means for demodulating the wobble signal that is detected based on reflected light from the information recording medium;

layer information detection means for detecting the layer information from the wobble signal that is demodulated;

address information detection means for detecting the address information from the wobble signal that is demodulated; and

discriminating means for discriminating the recording layer on which the light spot is formed based on the layer information and the address information.

19. The recording layer discriminating apparatus as claimed in claim 17 or 18, characterized in that the demodulating means comprises:

a clock generating circuit generating a reference clock from the wobble signal; and

a demodulating circuit demodulating the wobble signal based on the reference clock,

and that the layer information detection means comprises:

a synchronizing information detection circuit detecting the synchronizing information;

a counter counting a number of reference clocks using the synchronizing information as a starting point; and

a layer information detection circuit detecting the layer information based on a counted value of the counter.

20. An optical disk apparatus for carrying out at

least one of recording, reproduction and erasure of information with respect to an information recording medium, characterized in that the apparatus comprises:

a optical pickup unit forming a light spot on one of a plurality of recording layers via an objective lens, and receiving reflected light from said one of the plurality of recording layers;

a recording layer discriminating apparatus recited in any of claims 17 to 19, discriminating the recording layer on which the light spot is formed, based on the wobble signal that is detected from an output signal of the optical pickup unit;

a servo control unit controlling a position of the objective lens based on the output signal of the optical pickup unit and an output signal of the recording layer discriminating apparatus; and

a processing unit carrying out at least one of recording, reproduction and erasure of information via the optical pickup unit.

21. A recording medium characterized in that the recording medium comprises a plurality of recording layers, wherein a track on each of the recording layers has wobbles formed by a carrier wave part for causing detection of a carrier wave having a constant frequency and a layer

information part for causing detection of a frequency modulated wave indicating a place or position of the recording layer.

22. The recording medium as claimed in claim 21, characterized in that the frequency of the frequency modulated wave is 1/2 a carrier wave frequency.

23. The recording medium as claimed in claim 22, characterized in that a length of the frequency modulated wave amounts to 2 carrier wave periods.

24. The recording medium as claimed in 21, characterized in that a frequency of the frequency modulated wave is 2 times a carrier wave frequency.

25. The recording medium as claimed in claim 24, characterized in that a length of the frequency modulated wave amounts to 1 carrier wave period.

26. A recording medium characterized in that the recording medium comprises a plurality of recording layers, wherein a track on each of the recording layers has wobbles formed by a carrier wave part for causing detection of a carrier wave having a constant frequency and a layer

information part for causing detection of a phase modulated wave indicating a place or position of the recording layer.

27. A recording medium characterized in that the recording medium comprises a plurality of recording layers, wherein a track on each of the recording layers has wobbles formed by a carrier wave part for causing detection of a carrier wave having a constant frequency and a layer information part for causing detection of a phase modulated wave indicating a place or position of the recording layer and having a period different from that of the carrier wave.

28. The recording medium as claimed in claim 27, characterized in that the frequency of the phase modulated wave having the period different from that of the carrier wave is 1/2 a carrier wave frequency.

29. The recording medium as claimed in claim 28, characterized in that a length of the phase modulated wave having the period different from that of the carrier wave amounts to 2 carrier wave periods.

30. The recording medium as claimed in claim 27, characterized in that the frequency of the phase modulated wave having the period different from that of the carrier wave

is 2 times a carrier wave frequency.

31. The recording medium as claimed in claim 30, characterized in that a length of the phase modulated wave having the period different from that of the carrier wave amounts to 1 carrier wave period.

32. The recording medium as claimed in any of claims 21 to 31, characterized in that the layer information part is arranged between carrier wave parts.

33. An optical disk characterized in that the optical disk comprises a track having wobbles, wherein the wobbles form an FSK modulation part based on a waveform of first information subjected to an FSK modulation, a PSK modulation part based on a waveform of second information subjected to a PSK modulation, and a carrier wave part based on a constant frequency waveform, that are separate.

34. The optical disk as claimed in claim 33, characterized in that a frequency used for the FSK modulation is 1/2 a carrier wave frequency of the carrier wave part.

35. The optical disk as claimed in claim 34, characterized in that a length of unit information recorded by

the FSK modulation amounts to 2 carrier wave periods of the carrier wave part.

36. The optical disk as claimed in claim 33, characterized in that a frequency used for the FSK modulation is 2 times a carrier wave frequency of the carrier wave part.

37. The optical disk as claimed in claim 36, characterized in that a length of unit information recorded by the FSK modulation amounts to 1 carrier wave period of the carrier wave part.

38. The optical disk as claimed in claim 33, characterized in that a length of unit information recorded by the PSK modulation amounts to 1 carrier wave period of the carrier wave part.

39. The optical disk as claimed in claim 33, characterized in that the PSK modulation part is arranged between carrier wave parts.

40. The optical disk as claimed in any of claims 33 to 39, characterized in that the first information is address information, and the second information is layer information indicating a place or position of each of a

plurality of recording layers.

41. An optical disk characterized in that the optical disk comprises a track having wobbles, wherein the wobbles form an FSK modulation part based on a waveform of address information subjected to an FSK modulation, a first PSK modulation part based on a waveform of layer information subjected to a PSK modulation, a carrier wave part based on a constant frequency waveform, and a second PSK modulation part based on a waveform of periodic synchronizing signal subjected to a PSK modulation, that are separate.

42. An optical disk characterized in that the optical disk comprises a track having wobbles, wherein the wobbles form an FSK modulation part based on a waveform of address information subjected to an FSK modulation, a PSK modulation part based on a waveform of layer information subjected to a PSK modulation, a carrier wave part based on a constant frequency waveform, that are separate, and periodic synchronizing information is formed by pits.

43. The optical disk as claimed in any of claims 40 to 42, characterized in that a relationship between the address information and a radial position on the optical disk is the same for each of a plurality of recording layers.

44. The optical disk as claimed in any of claims 40 to 43, characterized in that the layer information is included in recorded information of a recorded part.

45. An optical disk characterized in that the optical disk comprises a track having wobbles, wherein the wobbles form a carrier wave part based on a constant frequency waveform, an FSK+PSK modulation part based on a waveform of first information subjected to an PSK modulation and having a period different from that of the carrier wave part, and a PSK modulation part based on a waveform of second information subjected to a PSK modulation, that are separate.

46. The optical disk as claimed in claim 45, characterized in that a frequency used for an FSK+PSK modulation of the FSK+PSK modulation part is 1/2 a carrier wave frequency of the carrier wave part.

47. The optical disk as claimed in claim 46, characterized in that a length of unit information recorded by the FSK+PSK modulation amounts to 2 carrier wave periods of the carrier wave part.

48. The optical disk as claimed in claim 45,

characterized in that a frequency used for an FSK+PSK modulation of the FSK+PSK modulation part is 2 times a carrier wave frequency of the carrier wave part.

49. The optical disk as claimed in claim 48, characterized in that a length of unit information recorded by the FSK+PSK modulation amounts to 1 carrier wave period of the carrier wave part.

50. The optical disk as claimed in claim 45, characterized in that a length of unit information recorded by the PSK modulation amounts to 1 carrier wave period of the carrier wave part.

51. The optical disk as claimed in claim 45, characterized in that the PSK modulation part is arranged between carrier wave parts.

52. The optical disk as claimed in any of claims 45 to 51, characterized in that the first information is address information, and second information is layer information indicating a place or position of each of a plurality of recording layers.

53. An optical disk characterized in that the

optical disk comprises a track having wobbles, wherein the wobbles form a carrier wave part based on a constant frequency waveform, an FSK+PSK modulation part based on a waveform of address information subjected to an PSK modulation and having a period different from that of the carrier wave part, a first PSK modulation part based on a waveform of layer information subjected to a PSK modulation, and a second PSK modulation part based on a waveform of periodic synchronizing information subjected to a PSK modulation, that are separate.

54. An optical disk characterized in that the optical disk comprises a track having wobbles, wherein the wobbles form a carrier wave part based on a constant frequency waveform, an FSK+PSK modulation part based on a waveform of address information subjected to an PSK modulation and having a period different from that of the carrier wave part, and a PSK modulation part based on a waveform of layer information subjected to a PSK modulation, that are separate, and periodic synchronizing information is formed by pits.

55. The optical disk as claimed in any of claims 52 to 54, characterized in that a relationship between the address information and a radial position on the optical disk is the same for each of a plurality of recording layers.

56. The optical disk as claimed in any of claims 52 to 55, characterized in that the layer information is included in recorded information of a recorded part.

57. An optical disk characterized in that the optical disk comprises a track having wobbles, wherein the wobbles form a carrier wave part based on a constant frequency waveform, and an FSK modulation part based on a waveform of layer information subjected to an FSK modulation, that are separate.

58. The optical disk as claimed in claim 57, characterized in that a frequency used for the FSK modulation is 1/2 a carrier wave frequency of the carrier wave part.

59. The optical disk as claimed in claim 58, characterized in that a length of unit information recorded by the FSK modulation amounts to 2 carrier wave periods of the carrier wave part.

60. The optical disk as claimed in claim 57, characterized in that a frequency used for the FSK modulation is 2 times a carrier wave frequency of the carrier wave part.

61. The optical disk as claimed in claim 60,

characterized in that a length of unit information recorded by the FSK modulation amounts to 1 carrier wave period of the carrier wave part.

62. The optical disk as claimed in any of claims 57 to 61, characterized in that the FSK modulation part is arranged between carrier wave parts.

63. An optical disk characterized in that the optical disk comprises a track having wobbles, wherein the wobbles form a carrier wave part based on a constant frequency waveform, and an FSK+PSK modulation part based on a waveform of layer information subjected to a PSK modulation and having a period different from that of the carrier wave part, that are separate.

64. The optical disk as claimed in claim 63, characterized in that a frequency used for an FSK+PSK modulation of the FSK+PSK modulation part is 1/2 a carrier wave frequency of the carrier wave part.

65. The optical disk as claimed in claim 64, characterized in that a length of unit information recorded by the FSK+PSK modulation amounts to 2 carrier wave periods of the carrier wave part.

66. The optical disk as claimed in claim 63, characterized in that a frequency used for an FSK+PSK modulation of the FSK+PSK modulation part is 2 times a carrier wave frequency of the carrier wave part.

67. The optical disk as claimed in claim 66, characterized in that a length of unit information recorded by the FSK+PSK modulation amounts to 1 carrier wave period of the carrier wave part.

68. The optical disk as claimed in any of claims 63 to 67, characterized in that the PSK modulation part is arranged between carrier wave parts.

69. An information recording medium forming apparatus for forming a track having wobbles on an information recording medium by irradiating thereon a light spot, characterized in that the apparatus comprises:

a recording apparatus irradiating the light spot on the information recording medium;

an irradiating position changing unit generating the wobbles of the track by changing an irradiating position of the light spot on the information recording medium;

a signal generator generating a plurality of signals

having different frequencies or having the same frequency but inverted phases; and

a selection unit selectively outputting the plurality of generated signals based on a predetermined signal,

wherein the irradiating position changing unit generates the wobbles based on the signals that are selectively output from the selection unit.

70. The information recording medium forming apparatus as claimed in claim 69, characterized in that:

the signal generator generates two signals having different frequencies; and

the selection unit selectively outputs the two signals to the irradiating position changing unit.

71. The information recording medium forming apparatus as claimed in claim 70, characterized in that:

the irradiating position changing unit forms the track on each recording layer by the recording apparatus by moving the position of the light spot to each recording layer, when the information recording medium has a plurality of data recordable recording layers; and

the selection unit uses the predetermined signal as layer information indicating a place or position of each recording layer.

72. The information recording medium forming apparatus as claimed in claim 69, characterized in that:

the signal generator generates two signals having different frequencies and one signal having an inverted phase of one of the two signals; and

the selection unit selectively outputs the three signals to the irradiating position changing unit.

73. The information recording medium forming apparatus as claimed in claim 70, characterized in that:

the irradiating position changing unit forms the track on each recording layer by the recording apparatus by moving the position of the light spot to each recording layer, when the information recording medium has a plurality of data recordable recording layers; and

the selection unit uses the predetermined signal as layer information indicating a place or position of each recording layer and position information indicating wobble numbers of the wobbles storing the layer information, selects one of the two signals having the same frequency but inverted phases of the three signals based on the layer information, selects one of the selected signal and a remaining one of the three signals having a frequency different from the selected signal based on the position information, and outputs the selected

signal to the irradiating position changing unit.

74. The information recording medium forming apparatus as claimed in claim 70, characterized in that:

the irradiating position changing unit forms the track on each recording layer by the recording apparatus by moving the position of the light spot to each recording layer, when the information recording medium has a plurality of data recordable recording layers; and

the selection unit uses the predetermined signal as layer information indicating a place or position of each recording layer, selects one of the two signals having the same frequency but inverted phases of the three signals based on the layer information, selects one of the selected signal and a remaining one of the three signals having a frequency different from the selected signal based on the position information, and outputs the selected signal to the irradiating position changing unit.

75. The information recording medium forming apparatus as claimed in claim 69, characterized in that:

the signal generates two signals having different frequencies and two inverted signals having inverted phases of the two signals; and

the selection unit selectively outputs the four signals

to the irradiating position changing unit.

76. The information recording medium forming apparatus as claimed in claim 70, characterized in that:

the irradiating position changing unit forms the track on each recording layer by the recording apparatus by moving the position of the light spot to each recording layer, when the information recording medium has a plurality of data recordable recording layers; and

the selection unit uses the predetermined signal as layer information indicating a place or position of each recording layer, address information and position information indicating wobble numbers of the wobbles storing the address information, selects one signal of one of two pairs of signals having the same frequency but inverted phases of the four signals based on the layer information, selects one signal of a remaining pair of signals having the same frequency but inverted phases based on the address information, selects one of the two selected signals selected by the layer information and the address information based on the position information, and outputs the selected signal to the irradiating position changing unit.

77. The information recording medium forming apparatus as claimed in any of claims 69 to 76, characterized

in that the apparatus comprises:

a clock generating unit generating a reference clock used by the signal generator to generate the signals,

wherein a frequency of the reference clock changes based on rotation information indicating a rotational speed of the information recording medium or radial position information indicating a radial position on the information recording medium.

78. An information recording medium forming method for forming a track having wobbles on an information recording medium by irradiating thereon a light spot, characterized in that the method comprises:

generating a plurality of signals having different frequencies or having the same frequency but inverted phases;

selectively outputting the plurality of generated signals based on a predetermined signal; and

generating the wobbles based on the signals that are selectively output by changing an irradiating position of the light spot on the information recording medium.

79. The information recording medium forming method as claimed in claim 78, characterized in that:

the generating of plurality of signals generates two signals having different frequencies; and

the selectively outputting selectively outputs the two signals.

80. The information recording medium forming method as claimed in claim 79, characterized in that the method comprises:

forming the track on each recording layer by moving a position of the light spot to each recording layer, when the information recording medium has a plurality of data recordable recording layers; and

wherein the selectively outputting uses the predetermined signal as layer information indicating a place or position of each recording layer.

81. The information recording medium forming method as claimed in claim 78, characterized in that:

the generating of plurality of signals generates two signals having different frequencies and an inverted signal having an inverted phase of one of the two signals; and

wherein the selectively outputting selectively outputs the three signals.

82. The information recording medium forming method as claimed in claim 81, characterized in that the method comprises:

forming the track on each recording layer by moving a position of the light spot to each recording layer, when the information recording medium has a plurality of data recordable recording layers; and

wherein the selectively outputting uses the predetermined signal as layer information indicating a place or position of each recording layer and position information indicating wobble numbers of the wobbles storing the layer information, selects one of the two signals having the same frequency but inverted phases of the three signals based on the layer information, selects one of the selected signal and a remaining one of the three signals having a frequency different from the selected signal based on the position information, and outputs the selected signal.

83. The information recording medium forming method as claimed in claim 81, characterized in that the method comprises:

forming the track on each recording layer by the recording apparatus by moving the position of the light spot to each recording layer, when the information recording medium has a plurality of data recordable recording layers; and

wherein the selectively outputting uses the predetermined signal as layer information indicating a place or position of each recording layer, selects one of the two signals having

the same frequency but inverted phases of the three signals based on the layer information, selects one of the selected signal and a remaining one of the three signals having a frequency different from the selected signal based on the position information, and outputs the selected signal to the irradiating position changing unit.

84. The information recording medium forming method as claimed in claim 78, characterized in that:

the generating of plurality of signals generates two signals having different frequencies and two inverted signals having inverted phases of the two signals; and

wherein the selectively outputs selectively outputs the four signals.

85. The information recording medium forming method as claimed in claim 84, characterized in that the method comprises:

forming the track on each recording layer by the recording apparatus by moving the position of the light spot to each recording layer, when the information recording medium has a plurality of data recordable recording layers; and

wherein the selectively outputting uses the predetermined signal as layer information indicating a place or position of each recording layer, address information and position

information indicating wobble numbers of the wobbles storing the address information, selects one signal of one of two pairs of signals having the same frequency but inverted phases of the four signals based on the layer information, selects one signal of a remaining pair of signals having the same frequency but inverted phases based on the address information, selects one of the two selected signals selected by the layer information and the address information based on the position information, and outputs the selected signal.

86. The information recording medium forming method as claimed in any of claims 78 to 85, characterized in that:

the generating of plurality of signals generates the signals based on a predetermined reference clock,

wherein a frequency of the reference clock changes based on rotation information indicating a rotational speed of the information recording medium or radial position information indicating a radial position on the information recording medium.

87. An information detecting apparatus for reading, from an information recording medium having a track formed with wobbles of modulated information, information recorded in the wobbles, characterized in that said apparatus comprises:

clock generating means for generating a reference clock from a wobble signal that is obtained from the wobbles;

demodulating means for detecting FSK modulated information, PSK modulated information or FSK+PSK modulated information from the wobble signal based on the reference clock signal;

synchronization detection means for outputting a timing signal that indicates a position of layer information indicating a place or position of each recording layer when the information recording medium has a plurality of data recordable recording layers; and

layer information detection means for detecting the layer information by holding an output of the demodulating means in response to the timing signal.

88. The information detecting apparatus as claimed in claim 87, characterized in that:

the demodulating means also detects the PSK modulated information from the wobble signal based on the reference clock signal when detecting the FSK+PSK modulated information; and

the synchronization detection means also generates a timing signal indicating a position of address information, in addition to the timing signal indicating the position of the layer information;

and that said apparatus further comprises:

address information detection means for detecting the address information by holding an output of the PSK modulated information in response to the timing signal indicating the position of the address information.

89. The information detecting apparatus as claimed in claim 87, characterized in that:

the demodulating means also detects the FSK+PSK modulated information from the wobble signal based on the reference clock signal when detecting the PSK modulated information; and

the synchronization detection means also generates a timing signal indicating a position of address information, in addition to the timing signal indicating the position of the layer information;

and that said apparatus further comprises:

address information detection means for detecting the address information by holding an output of the FSK+PSK modulated information in response to the timing signal indicating the position of the address information.

90. An information recording medium apparatus for recording or reproducing information with respect to a recording layer of an information recording medium by irradiating light thereon, said information recording medium

having a plurality of data recordable recording layers, characterized in that the apparatus comprises:

an optical system detecting a wobble signal from wobbles formed on a track of the information recording medium, from reflected light that is reflected from the information recording medium when light is irradiated on the information recording medium; and

an information detecting apparatus as claimed in any of claims 87 to 89 for detecting the information from the wobble signal,

wherein the recording or reproducing information with respect to the information recording medium is carried out based on the information obtained by the information detecting apparatus.

91. An information detecting method for reading, from an information recording medium having a track formed with wobbles of modulated information, information recorded in the wobbles, characterized in that said method comprises:

generating a reference clock from a wobble signal that is obtained from the wobbles;

detecting FSK modulated information, PSK modulated information or FSK+PSK modulated information from the wobble signal based on the reference clock signal; and

detecting layer information by holding the information

detected from the wobble signal in response to a timing signal that indicates a position of the layer information indicating a place or position of each recording layer when the information recording medium has a plurality of data recordable recording layers.

92. The information detecting method as claimed in claim 91, characterized in that the detecting the layer information also detects the PSK modulated information from the wobble signal based on the reference clock signal when detecting the FSK+PSK modulated information, and detects address information by holding an output of the PSK modulated information in response to a timing signal indicating a position of the address information.

93. The information detecting method as claimed in claim 91, characterized in that the detecting the layer information also detects the FSK+PSK modulated information from the wobble signal based on the reference clock signal when detecting the PSK modulated information, and detects address information by holding an output of the FSK+PSK modulated information in response to a timing signal indicating a position of the address information.

94. An information recording medium having a

plurality of recording layers recordable with data by irradiating light thereon, and a track on each recording layer includes wobbles of modulated information, characterized in that:

the wobbles are recorded with FSK modulated information, PSK modulated information or FSK+PSK modulated information as layer information indicating a place or position of each recording layer.

95. The information recording medium as claimed in claim 94, characterized in that the wobbles are further recorded with PSK modulated information as address information when the layer information is the FSK+PSK modulated information.

96. The information recording medium as claimed in claim 94, characterized in that the wobbles are further recorded with FSK+PSK modulated information as address information when the layer information is the PSK modulated information.